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Statement of

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Chair, Aerospace Safety Advisory Panel

before the

Subcommittee on Science, Technology and Space
Committee on Commerce, Science and Transportation

United States Senate

September 6, 2001

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Response to Questions by the

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Based on Hearings Conducted on

September 6, 2001

1) What type of investments in the Space Shuttle do you believe will be needed to allow NASA to reap the full benefits of the Space Station?

The Space Shuttle is the major resupply and crew transfer vehicle for the International Space Station (ISS). Its capabilities with respect to crew and payload size are unmatched by any other human-rated space vehicle. The Space Shuttle is the only vehicle servicing the ISS that is capable of returning payloads and science results from orbit. It has also been providing significant reboost for the ISS thereby reducing reliance on Russian Progress vehicles. It is essential to keep the Space Shuttle as reliable and safe as possible since it is the key element in the ISS logistics chain. The Aerospace Safety Advisory Panel is concerned that both the safety and reliability of the Space Shuttle are being compromised in the long term because of lack of investment in four areas:

- Flight systems – Many of the subsystems of the Space Shuttle are aging and likely cannot support flight at current risk levels for the entire expected service life of the total system. For many others, advancing technology has provided ways to reduce risk significantly if improved components are designed, developed, tested and certified. The Panel believes that, at a minimum, significant investment above and beyond current budget levels are required just to retain present safety margins over the next 20 or more years. Additional expenditures are warranted in areas for which risk can be meaningfully reduced from those produced by the original design. In both cases, it is important to recognize that the long lead times involved in manufacturing current components or designing and qualifying improved replacements dictate the need to make investments now so that the Space Shuttle is fully capable of safely meeting the flight needs for ISS support.

- Renewal of the ground infrastructure – Investment is critically needed to revitalize the launch facilities, ground support equipment, laboratories and test and checkout gear needed to support safe Space Shuttle flights. A significant portion of this infrastructure is over 30 years old, and continual budgetary pressures have forced the deferral of much needed maintenance and replacement. The ISS cannot be supported adequately if these ground assets force a reduced flight rate or a temporary grounding of the Space Shuttle. Safety of the Space Shuttle can be compromised by unreliable ground infrastructure. Interruptions of Space Shuttle flights would also markedly impact the chance of ISS mission success. The Panel believes that NASA must be able to make proactive investments in ground infrastructure to prevent failures and assure the availability of flight support for the ISS.

- Logistics -- Providing for the timely availability of properly functioning components throughout the projected life of the Space Shuttle is essential to its ability to support the ISS. Many items for the flight vehicle and ground support equipment are not in sufficient supply to carry the program until a viable replacement vehicle is qualified. Therefore, in addition to making sure that flight systems and ground infrastructure are as capable as possible, NASA must invest to ensure that there are sufficient assets readily available to support safe and effective operations for the lifetime of the Space Shuttle. The Panel believes that investment both for parts and in refurbishment capability is warranted.

- Workforce – The Space Shuttle is a complex system that will always depend on the ability and insight of a trained and experienced workforce for safe operation. Over the years, there has been a "natural" succession of Space Shuttle leaders. Experienced managers mentored younger members of the workforce and prepared them to assume leadership roles. Recent staff cutbacks and hiring freezes have created a gap in the ranks. Future budget limitations suggest that replenishing the "understudies" will be difficult. The Panel believes that NASA should be in a position to invest in the hiring and nurturing of future Space Shuttle managers. Such an investment would also create a cadre from which the leaders of future human spaceflight programs could be drawn just as many Space Shuttle veterans received their initial experience on the Apollo Program.

2) You have mentioned four areas of which the ASAP considers critical to the long-term operation of the Shuttle: flight system improvements, renewal of ground infrastructure, logistics and workforce.

Did the Panel place these in any order of priority for NASA?

All four of these areas are critical over the expected service life of the Space Shuttle. The most immediate priority area, however, is likely maintaining and augmenting the workforce. This will provide the leadership necessary to direct the actions in the other three areas. Flight system improvements and infrastructure revitalization must also be given an immediate priority because of the relatively long lead times involved in their implementation. Some logistics actions can await decisions between the simple replacement of aging components and the development of improved substitutes.

3) You have mentioned that any replacement for the Shuttle likely would not be more capable than the current system with appropriate upgrades. Can you elaborate on this conclusion?

One or more major technological advances will be needed in order to advance the state-of-the-art of human-rated spaceflight vehicles beyond the level of the Space Shuttle. For example, more efficient propulsion systems operating at lower stress levels could profoundly alter both the safety and cost of placing humans into earth orbit.

At present, there are no major technological breakthroughs available upon which a new, safer and more capable Space Shuttle replacement could be based. Upgrades have been identified, such as the electric auxiliary power unit and advanced health monitoring of the Space Shuttle main engines, which could improve the safety and reliability current vehicle. These same features would likely be standard equipment in any new vehicle designed today. Although they represent significant improvements, they are not the basis for a radical, new system design.

4) You have mentioned the impact of budgetary constraints on the program. For the Advisory Panel's review of the program, did you find that management of existing funds was sufficient?

The Aerospace Safety Advisory Panel is chartered to examine the safety of NASA's operations. When appropriate, we will highlight budget shortfalls that we believe have the potential to be detrimental to safety. We do not trace the management of existing funds to determine if it is sufficient. Over the likely service life of the Space Shuttle, however, the

magnitude of the present projected budget shortfall appears to be beyond the ability of any management to correct while still flying safely and meeting program objectives.

5) You have mentioned that the Panel is particularly concerned about infrastructure at KSC. How do the infrastructure problems at KSC compare to the needs at other NASA centers?

All of the human spaceflight centers are facing similar infrastructure problems because the maintenance and restoration of key facilities has been continually deferred. The situation at KSC is of particular concern to the Aerospace Safety Advisory Panel because it has the most direct potential impact on Space Shuttle safety. Other centers evidence similar examples of obsolete and worn infrastructure, but the preponderance of infrastructure related to the preparation and launch of the Space Shuttle is at KSC. Many of the KSC facilities are legacies from the Apollo Program. Assets such as the data cables to the launch pads are old and deteriorated and are only being kept operational through the ingenuity of the workforce. This cannot continue indefinitely.

6) How would you recommend capturing the knowledge of the current workforce for future use?

There are numerous emerging techniques for "mining" experience that have been developed as part of knowledge engineering efforts. Basically, however, two fundamental conditions must be satisfied before any sophisticated efforts can be effective. First, there must be an adequate supply of suitable replacement candidates within the operations of NASA and its contractors. If these individuals overlap the tenure of the current workforce, those with the best experience and knowledge can mentor them. This is an ideal way to perpetuate quality.

Second, once there is an adequate pipeline of prospective replacements, each entity within NASA must have a long range training and relief plan. Such a plan identifies each person who has a planned termination (retirement, resignation or transfer) as soon as it is known and designates a trainee, new hire or promotion candidate whose task it will be to capture the knowledge of the departing person. Since every worker is included, each can see his or her "career path" and identify the knowledge domain that will eventually be their responsibility.

7) Your testimony states that the requirements for flying the Space Shuttle at an acceptable level of risk is achieved only through the innovation and tireless efforts of an experienced workforce. NASA Administrator Goldin has testified that a large portion of NASA's workforce is aging and about to retire. What effects will large-scale retirements of experienced NASA and contractor personnel have on Shuttle safety?

This question touches at the crux of the concerns of the Aerospace Safety Advisory Panel. As the Space Shuttle ages, it will require innovative technical and management initiatives to continue flying safely. Large-scale retirements of experienced NASA and contractor personnel will deprive the Program of the highly experienced people needed to formulate and execute these initiatives. It will therefore become increasingly difficult to know when the illusive line between safe and unsafe operations is being approached, and safety risk will almost assuredly increase.

The Panel believes that two major actions are needed now to compensate for the likely departure of much of the government and contractor talent responsible for safe Space Shuttle

operations. First, as discussed above, both NASA and its contractors should begin a vigorous hiring program as soon as possible so people will be available to work at the sides of the prospective retirees before they leave. Second, the experienced workforce should be given the means to execute a meaningful life extension program for the Space Shuttle. If modeled after successful commercial and military aircraft life extension programs, this effort will reduce safety risk and simplify the tasks facing future generations of Space Shuttle managers. This will reduce rather than increase the reliance of the Space Shuttle on workforce experience to maintain safety.

8) You also said that NASA must fund EAPU and other upgrade development and certification "at the expense of activities needed to continue flying safely at present." What creates this tradeoff? Should NASA's Human Space Flight account be restructured to prevent tradeoffs like these in the future?

Insufficient funding to meet present flight objectives and make appropriate investments for the future creates the referenced tradeoffs. When managers are faced with this dilemma, they have only two viable choices—defer upgrades and expenditures for the future or reduce current operations. The Space Shuttle program cannot reasonably reduce the present flight rate and still adequately support the construction and utilization of the ISS. Therefore, planning horizons have been severely limited to provide for current needs. Although this maintains current Space Shuttle safety, it has created serious concerns on the part of the Panel about the ability of the Program to maintain or improve risk levels in the future.

9) Your testimony also highlights that the infrastructure situation becomes worse each year due to a growing backlog. What can NASA and Congress do to reverse the trend in this problem and ensure greater emphasis on the infrastructure maintenance?

This is purely a budget issue. Present funding is insufficient to support current operations, flight system improvements and infrastructure backlog reduction. NASA and contractor managers are well aware of the infrastructure weak spots. With adequate resources and a reasonable degree of flexibility, they can reverse the trend and begin improving the situation rather than letting it deteriorate further. Giving management prerogative to NASA and its contractors is essential because the relative priority of various infrastructure revitalization efforts can shift over time due to circumstances beyond the control of the Program.

10) You have also stated today that logistics is a serious problem that is affecting the Space Shuttle Program. For example, the long lead times for the manufacture of critical components creates logistical problems and cannibalization. Can NASA use other contracting and purchase strategies, such as are used by commercial companies, to reduce these logistical bottlenecks?

In general, the long lead times NASA faces are due to the unique nature of the components in question. They are a technical rather than a management issue. Some critical components take a year or more to manufacture. Given the small production runs involved, it is likely not cost effective to invest significant sums to develop and qualify new, more rapid manufacturing techniques. NASA and its contractors must therefore accept the lengthy production schedules and plan sufficiently far in advance to ensure an adequate supply of components.

Mr. Chairman and Distinguished Members of the Subcommittee:

I am pleased to appear before you today to summarize the Aerospace Safety Advisory Panel's current view of Space Shuttle safety. Both NASA and its contractors are handling near-term Space Shuttle safety admirably. Our primary concern, therefore, relates to the long-term picture, which has seemingly deteriorated since we highlighted it in our last annual report. The Space Shuttle cannot continue indefinitely at an acceptable level of risk unless appropriate steps are taken now.

There are four areas that we believe are critical to long-term Space Shuttle safety. The first deals with flight system improvements that reduce the risks associated with the servicing and use of flight hardware.

Unfortunately, budgetary pressures have forced the Space Shuttle program to eliminate or defer many needed upgrades. The Panel does not think this is prudent because it means the system must continue to operate at a higher risk level than is necessary resulting in a lost safety opportunity. Under present guidelines upgrades must be funded at the expense of activities needed to continue flying safely in the present. No program should be forced into a position in which tradeoffs between current and future safety are required.

The Panel cautions that now is not the time for significant cutbacks. At this stage in the life of a complex vehicle that will likely remain in service for several more decades, increased rather than diminished risk reduction efforts are essential.

Our second focal area relates to the renewal of the ground infrastructure including facilities, ground support equipment and test and checkout gear. These assets, like the vehicle itself, are aging. Much maintenance and improvement of this infrastructure has been deferred to conserve resources for operations. As a result, there is a large backlog of restoration and upgrade work. If needed efforts are delayed further, it may become impossible to catch up.

Aging infrastructure becomes unreliable. Safety can be compromised when systems fail at inopportune times or multiple, simultaneous failures occur.

The third area requiring attention is logistics. An aging flight vehicle faces logistics challenges not only from wear and tear but also from obsolescence. Some suppliers lose skills when they stop production. Others go out of business or lose interest in maintaining capabilities when relegated to a minor support role.

Space Shuttle logistics is hampered by a lack of sufficient assets to support the program for its likely service life. Where total inventory ***is*** adequate, flight-ready spares are still often less than desirable because of slow repair turnaround times.

NASA must analyze its logistics needs for the entire projected life of the Space Shuttle and adopt a realistic program for acquiring and supporting sufficient numbers of suitable components and maintaining a key

supplier base. Acquisitions must be made soon because of the long lead times for some complex, safety-critical Space Shuttle components.

The final area I would like to highlight deals with workforce. NASA and its contractors are inexorably losing experienced workers to retirement. Previous downsizing and hiring freezes have limited the available numbers of fully qualified successors. This projected loss of experience need not be detrimental to future safety if ***current*** planning is adequate to present the next generation of Space Shuttle managers with reasonable tasks. The knowledge and experience of current personnel must be captured and transferred to the future workforce if safety and efficiency are to be maximized.

In summary, in order to fly safely until 2020 and beyond, the Space Shuttle will need improvements, additional care, infrastructure revitalization, better logistics, a skilled and experienced workforce and development of an operational posture consistent with the capabilities of that workforce. The longer that these vital steps are postponed, the harder they will be to accomplish, the more they will cost and the higher will be the safety risk. The preferred alternative is to acknowledge ***now*** the role of the Space Shuttle as our human spaceflight vehicle for the foreseeable future and to care for the total system appropriately in a timely manner.

The boundary between safe and unsafe operations can never be well defined. As equipment and facilities age and workforce experience is lost, the likelihood that the line will be inadvertently crossed even by

well meaning managers increases. The best way to prevent problems is to be proactive and continuous with risk reduction efforts. The Panel fears that the Space Shuttle program is not being allowed to do this and, in fact, has been forced to forego appropriate long-term planning in order to maximize the safety of present operations. This is not a wise approach, and we hope it will not continue.

Thank you for this opportunity to present the thoughts of the Aerospace Safety Advisory Panel. I stand ready to answer any questions you might have.